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ESTABLISHING A COMMERCIAL RESERVE IMAGERY FLEET OBTAINING SURGE IMAGERY CAPACITY FROM COMMERCIAL REMOTE SENSING SATELLITE SYSTEMS DURING CRISIS

by

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Preface

Recent developments in commercial satellite imagery have garnered worldwide attention. In particular, the United States Congress implied through recent legislative actions that this trend toward remote sensing commercialization could be of great benefit to the country by expanding our capabilities, ensuring the United State's technology base, and reducing the cost of reconnaissance services. Congress jointly tasked the Director of the National Reconnaissance Office (NRO) and the Director of the National Imagery and Mapping Agency (NIMA) in 1998 to determine the appropriate course of action for integrating commercial imagery collection and services into the Intelligence Community architecture. One result of that study proposed a Commercial Reserve Imagery Fleet (CRIF) to supplement national capability during a crisis, based on the successful Civil Reserve Air Fleet (CRAF) model developed for airlift support. This paper determines if a reserve imagery fleet is needed, what conditions are necessary prior to implementation and how the concept should be developed, using lessons learned from the CRAF to expedite implementation.

I would like to thank the many people who took the time to evaluate this paper in its many stages. In particular, I would like to thank Ms. Laura Robinson, NIMA Commercial Imagery Program, for helping me focus the topic of my research and for her valuable perspective on the final review. I also owe a big thank you to my wife, Jennifer, for her painstaking editing of the second revision. A huge thanks goes to my research advisor, Major Kim Sievers, for her detailed reviews and many helpful suggestions. I would also like to thank Jeff Kerridge of EarthWatch,

Gary Fuller (formerly of Space Imaging), and Joe Dodd of ORBIMAGE for their most valuable insight into their companies' business models. This insight resulted in a proposal for a CRIF model acceptable to both the U.S. government and industry.

Abstract

Precision-guided weapons employment during and since the Gulf War highlights the critical role space assets, particularly reconnaissance systems, play in modern military operations. This, along with other developments, has led to a proliferation of commercial satellite remote sensing systems. Congress directed the National Reconnaissance Office and National Imagery and Mapping Agency to investigate commercial satellite imaging systems as a supplement to national reconnaissance systems. This paper investigates one of the recommendations in the response to Congress: the development of a Commercial Reserve Imagery Fleet (CRIF) to augment national imagery systems during crises. The CRIF concept is explored in detail using the successful Civil Reserve Air Fleet (CRAF) model that supplies surge airlift capacity for comparison.

The first question that must be answered is why establish a CRIF? There are at least three reasons, the principal being money. In the current budgetary and strategic environment, Congress will not continue to fund the development of national imagery systems to meet ever-expanding requirements, particularly surge requirements expected during crises. Congress desires to leverage the investment being made in the commercial remote sensing market to reduce the burden on the taxpayer. Second, the path is historically proven. The development of aviation technology followed a similar course when the CRAF was instituted to reduce government costs while meeting surge airlift requirements. Third, valid requirements for surge imagery capacity exist that can be fulfilled by current commercial imagery systems.

The necessary conditions for establishing a CRIF are then examined. The development of the early US aviation industry is reviewed to identify the conditions that led to the formation of the CRAF. This history is compared to current developments in commercial remote sensing to identify necessary preconditions for implementation of a CRIF. The two primary preconditions are a legally established and workable incentive program to reward commercial companies for participation and a detailed evaluation of surge imagery requirements. Once met, these two items can then be adjusted to balance CRIF imagery supply with surge requirement demand.

Finally, details of how a CRIF might be implemented are discussed. The development and evolution of the Civil Reserve Air Fleet is analyzed, highlighting key organizational, contractual, and logistical issues that existed during CRAF development. The CRIF concept is then outlined, highlighting the contractual, organizational and logistical arrangements, financial and physical risks for CRIF participation, and security and classification issues.

This research concludes that establishing a CRIF is almost a certainty, but the time is not yet right for implementation. The commercial satellite imagery industry is young and parallels the development of commercial aviation during the mid-1920s. Although the need for a CRAF was recognized as early as 1934, it took maturing of the industry and two major crises before the CRAF was established in 1951. Likewise, the commercial remote sensing industry needs to mature further. Additionally, the two primary preconditions identified earlier need to occur before a workable CRIF is feasible.

Establishing a CRIF can fill a void for imagery during a crisis and may maintain or improve imagery reconnaissance services for the US while reducing the cost to the taxpayer. The history of the CRAF leads to the conclusion that this will almost certainly happen. If steps are taken to accelerate the two CRIF implementation conditions, the US can benefit sooner rather than later.

Part 1

Introduction

> *Combat aircrews at the wing level requested a steady flow of target materials, especially imagery. At one end of the spectrum were systems such as the Tomahawk Land Attack Missile and the F-117 that had prodigious requirements for specialized information. But even in the case of fighter-bombers with less exacting requirements for mission planning, the appetite for target imagery and threat information in the units proved well-nigh insatiable.*
>
> — Gulf War Air Power Survey

The expanded use of precision guided-munitions and the need for near-real-time targeting during and since the Gulf War has created an ever-increasing demand for high-resolution imagery for military planning.[1] Unfortunately, intelligence assets have always fallen into the category of low density/high demand (LD/HD) resources. In particular, satellite imagery systems are constrained by orbital mechanics to the number of images they can take over a specific area in one day. In the future, it is highly likely that demands on existing national assets will outstrip supply, particularly during a regional crisis.[2] Thus the need for a way to augment national systems becomes evident. This paper investigates the development of a Commercial Reserve Imagery Fleet (CRIF) to augment national imagery systems during crises. The CRIF concept is explored in detail using the successful Civil Reserve Air Fleet (CRAF) model that supplies surge airlift capacity for comparison.

A new era in space started last year with the launch of the first truly commercial high-resolution imagery satellite on September 24, 1999. Space Imaging's IKONOS spacecraft is the

first privately owned, high-resolution imaging satellite to be successfully launched and operated.[3] It is also the most capable imaging satellite currently available on the open market, providing unprecedented resolution and timely access to any spot on the Earth to anyone with a credit card. Additionally, EarthWatch and ORBIMAGE plan to launch competing pairs of satellites starting this year, resulting in a potential "constellation" of five, one-meter resolution satellites on orbit by 2002.[4]

This development builds on recent history that points toward a powerful force multiplier; The Gulf War was called "the first space war" because of the integrated role space assets played, many for the first time.[5] The fact that the coalition controlled all imagery satellites provided a strategic advantage that fueled the new commercial market. Based on increased attention given to satellite remote sensing systems after the Gulf War, many countries started pursuing development of their own capabilities. At the same time, United States (US) satellite builders put pressure on Congress to update the Land Remote Sensing Act in 1992 to allow US companies to compete in the expanding global market for commercial satellite imagery. This move was meant to support and expand the US industrial base in this key technology area and protect our current technological advantage.[6] Additionally, it appears that congressional intent is ultimately to reduce the cost of acquiring imagery for national security purposes by relying on more commercial imagery in the future.[7] This situation is highly analogous to the one that existed in the early 1900s with the development of military and commercial aviation. Although a robust commercial aviation industry was not envisioned early on, it ultimately developed into a national resource, able to supplement military airlift when needed. Thus, several sources suggested that commercial space assets could be used to augment national space systems during times of crisis

based on the Civil Reserve Air Fleet model for commercial airlift.[8] This paper investigates the development of the Commercial Reserve Imagery Fleet.

Scope

This paper attempts to answer three questions on the concept of a CRIF: First, do we need a CRIF? Second, if a CRIF is needed, what are the necessary conditions for establishing a CRIF and have these conditions been met? Third, once the pre-conditions have been established, how should a CRIF be designed? To answer these questions the history of the CRAF is explored to find useful lessons learned from the establishment and operation of the CRAF. Then the history and unique aspects of commercial satellite imagery are explored and analyzed to see where the CRAF model fits, where it doesn't and suggest a model that is appropriate for a CRIF.

Notes

[1] Thomas A. Keaney, and Eliot A. Cohen, *Gulf War Air Power Survey. Summary Report*, (Washington, D.C.: United States, Department of the Air Force, 1993), 135.

[2] Keith Hall, "Media Roundtable Transcript," Director NRO, 8 July, 1999

[3] Joseph C. Anselmo, "Commercial Space's Sharp New Image," *Aviation Week & Space Technology* (Washington, 31 January 2000), 52-7. See also ORBIMAGE, "OrbView-1: Low-Cost, High-Value Weather Information," n.p.; on-line, Internet, 20 March 2000, available from http://www.orbimage.com/satellite/orbview1/orbview1.html. ORBIMAGE launched the first truly commercial imaging satellite, OrbView-1 in April 1995. This satellite provides weather and lightning data for atmospheric monitoring and research. The imaging instrument has a resolution of 10 km. IKONOS is the first "high-resolution" commercial imaging satellite.

[4] Joseph C. Anselmo, "Commercial Space's Sharp New Image," *Aviation Week & Space Technology* (Washington, 31 January 2000), 52-7.

[5] James Oberg, "Spying for Dummies," *IEEE Spectrum* (3 Park Avenue, New York, NY, November 1999), 62.

[6] Office of the Press Secretary, The White House, *Foreign Access to Remote Sensing Capabilities Fact Sheet, PDD-23* (March 10, 1994).

[7] *Intelligence Authorization Act for Fiscal Year 2000*, Public Law 106-120, 106th Cong., (2000), section 703 and comments on section 701. See also *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 4. (SECRET/SCI/PROPIN) Information extracted is unclassified.

[8] Researching this topic revealed three nominally independent sources for the CRIF idea. See Commercial Imagery Program, National Imagery and Mapping Agency, *Frequently Asked*

Notes

Questions, NIMA Use of Commercial Imagery (October 15,1999). See also Chris Allen, "Civil Reserve Imaging Fleet Proposal," Proposal viewgraph slides, NIMA/PAS, (Bethesda, MD), NIMA/PAS. See also Institute for National Security Studies, "Space Policy - Topic 14, Propose New Business Practices Whereby the US Military Can Obtain Needed Surge Capacity on Commercial Systems During Times of Crisis," Air University Research Topics, 9 August 1999, on-line, Internet, 6 October 1999, available from http://research.maxwell.af.mil/Topics_Database/display_topic.asp?topicNbr=326.

Part 2

Why a CRIF?

> *[It] has not been politically or economically feasible to maintain in peacetime the airlift capability considered necessary in meeting wartime airlift requirements.*
>
> — Maj Kirk L. Brown

Given there is a requirement for surge imagery capacity during crisis, it is not obvious that a Commercial Reserve Imagery Fleet is the proper solution. This section addresses three reasons why a CRIF is needed. First, Congress appears intent on reducing the cost of providing satellite reconnaissance capability for the United States. They are hoping that commercial remote sensing satellites will eventually perform a significant portion of the day-to-day imaging requirements, enabling a leaner and less costly government reconnaissance system. Second, looking at the historical development of aviation provides a lesson that is difficult to ignore. The parallels between the development of commercial aviation and commercial remote sensing offer CRAF as a strong precedent for a commercial reserve imagery concept. Third, future imagery requirements, as documented in the Community Imagery Needs Forecast (CINF),[1] point to a CRIF-type system as an effective way to augment national capability, especially for surge capacity. Each of these three points will be discussed in detail in the following three sections.

Congressional Support

The Intelligence Authorization Act for Fiscal Year 2000 most vividly portrays the mood of the current Congress to move towards increased reliance on commercial imagery. Title VII of the Act calls for a National Commission for the Review of the National Reconnaissance Office (NRO). The duties of the commission include "review(ing) the current organization, practices, and authorities of the NRO, in particular with respect to…use of commercial imagery." The notes to the Act provide further explanation:

> [T]he managers determined that an independent review of the National Reconnaissance Office (NRO) must be conducted to ensure that the Intelligence Community will acquire the most efficient, technologically capable, and economical satellite collection systems…the changing threat environment and emerging technologies have altered both what information satellites can collect and how they collect it. Additionally, Congress wants to ensure that future generations of intelligence collection satellites both perform to their requirements and are purchased at a fair cost to the taxpayer.[2]

Additionally, the directors of NIMA and the NRO have proposed a nearly $1 billion program over the next six years to increase the involvement of commercial providers in the US Imagery and Geospatial Information Service (USIGS)—the system that provides imagery services to the government. While it is still too early to tell if this program will be fully implemented, it appears to have support on Capitol Hill.[3] This support, along with congressional drive to reduce the cost of reconnaissance services, is reason enough to develop a CRIF, however there is also strong historical precedent as well.

Historical Precedent

Early History of Commercial Aviation

The military directed and funded a large portion of the initial development of aviation before, during, and after World War I (WWI).[4] During WWI, the Army was not able to handle

its wartime requirements and continue delivering mail for the Post Office, so the Post Office won permission to start its own air mail delivery service. The contract airlines that sprung up in the 1920s as a result of this eventually became parts of United, American and Trans World Airways.[5] Additionally, America's late entry into WWI caused aircraft manufacturing to gear up just as the war was ending. This left a robust post-war aircraft manufacturing capability with no immediate customer. Aircraft were therefore available at bargain prices, further fueling the initial development of air commerce.[6]

Several important government actions during this time helped establish commercial aviation. In 1925, Congress passed the Kelly Act. This was the first national policy to promote commercial aviation, providing "for commercial contracts for small connecting routes to supplement the Post Office's own transcontinental service."[7] After many smaller studies, Congress appointed the Baker Board in 1934 to study the relationship between government and military aviation. This board made a number of recommendations. The first was that the government form a close relationship with civil aviation, but the two entities should remain separate. The second recommendation was that commercial airlines could be used as a reserve for national defense purposes. This was the first recorded recommendation for a civil air reserve, but was not acted upon until after our WWII and Berlin Airlift experiences, which proved the value of commercial airlift to the nation.[8] At the same time, commercial airline companies repeatedly argued that the military airlift system provided unfair competition with civil airlines and that commercial companies should get most, if not all government business.[9] This pattern of developments appears to be repeated in the commercial satellite imagery business.

History of Commercial Imagery Satellites

Like aviation, the government initially developed imagery satellites for official purposes. The Corona program launched the first successful, albeit classified, high-resolution system (nominally 11m) in 1960.[10] Around the same time, several countries launched unclassified, civil satellite remote sensing systems. The US launched the 1km resolution TIROS system starting in 1960 and followed up with the 30m resolution Landsat series, starting with Landsat 1 (80m resolution) in 1972.[11]

The Persian Gulf War saw the first public showcasing of imagery and other services from space providing increased combat effectiveness.[12] Like WWI's role in aviation, this crisis event highlighted the use of space imagery and was a catalyst driving increased development of this technology. Coalition forces made substantial use of unclassified imagery from the French civil imagery satellite system, SPOT. SPOT 1 was launched in 1986 and delivered 10m resolution panchromatic and 20m resolution multi-spectral imagery for sale on the open market. In the 1990s, SPOT was followed by systems built by the European Union, India, Japan and Canada, while many other countries were developing similar systems.[13]

Under pressure from US satellite builders, the US updated the Land Remote Sensing Act in 1992 to allow US companies to compete in the expanding global market for commercial satellite imagery. This move was meant to ensure and expand the US industrial base in this key technology area and protect our current technological advantage.[14] This act was similar to the Kelly Act of 1925 for commercial aviation, establishing the first national policy for a new technology in response to growing commercial concern.

The commercial remote sensing community is currently discussing the role of commercial imagery satellites in the government architecture and competition between commercial and government systems in the marketplace with Congress and the Intelligence Community (IC).[15] It

is possible that the Congressional NRO review dictated in this year's Intelligence Authorization Act could produce a congressional commercial imagery declaration similar to the Baker Board's civil aviation declaration in 1934; however, this remains to be seen. If such a declaration were made, the only item missing to complete the analogy between aviation and imagery satellites is a major crisis (or crises) that required surge imagery to parallel the use of commercial aviation during WWII and the Berlin Airlift.

Summary of Historical Parallels

There are three important parallels between the development of civil aviation and the commercial satellite imagery industry. First, early development of both technologies was driven by the military for exclusively military requirements. Second, as the technology became more accepted, refined and cost effective, commercial applications developed. Third, the initial

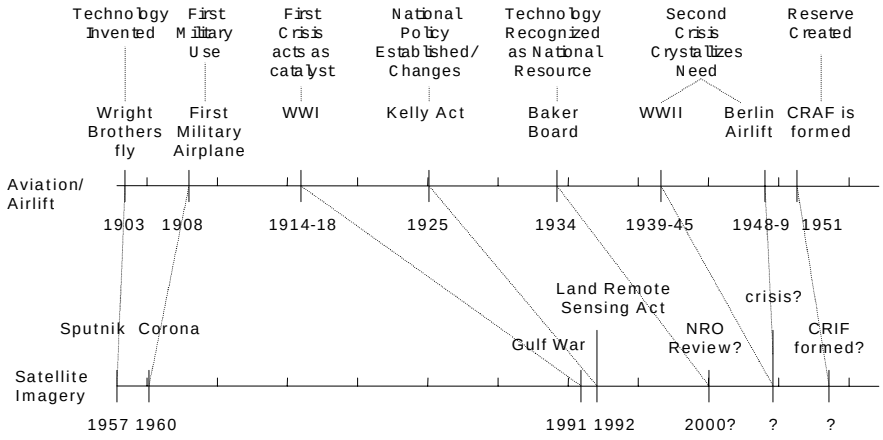

Figure 1 Airlift and Satellite Imagery Timeline Comparison

commercial applications were heavily government subsidized, with truly private applications developing later. Referring to Figure 1, it is clear that the commercial satellite imagery industry is in a state of development similar to commercial aviation between 1925 and 1934. It was during this time that commercial aviation blossomed, became economically viable and developed into a national resource that was first tested during World War II and the Berlin Airlift. The CRAF was officially established sixteen years later in 1951.

From this perspective, discussions of a CRIF are clearly the ground floor of an effort that will need to mature and evolve as the commercial satellite imagery industry develops and becomes commercially viable. However, these changes may occur more rapidly as the current pace of technology and business development is much greater than in the 1930s. It is also possible, that a near-term crisis could also accelerate this process.

Requirement for Surge Imagery

Lastly, the most important reason to develop a CRIF is that there is a real surge requirement for imagery that cannot be met by current or programmed government systems. There is much debate on this issue. Some argue a surge requirement is self-evident. During crises, limited assets like airlift and reconnaissance systems are always overtasked and requirements far exceed capacity.[16] Others argue that the proposed NRO Future Imagery Architecture (FIA), the programmed next generation of national imagery satellites and ground stations, will provide more than enough capacity to meet all future requirements.[17] A detailed treatment of this issue is beyond the scope of this study. However, the recent NIMA/NRO Commercial Imagery Strategy (CIS) study provides the most detailed effort to date investigating the use of commercial imagery. The CIS conducted several analyses using the CINF that studied different combinations of national and commercial constellations. The CIS study confirmed that commercial imagery

systems could meet surge requirements.[18] Mr. Keith Hall, Director of the NRO, amplified this point during a media round table discussion:

> What we have found in our imagery architecture and one of the main things of FIA is not how many pictures you can take in a day, but how many pictures can you take over Kosovo in a day. It is a lot less what you can take over Kosovo than what you can take over the world. And in those type of situations, I would anticipate that a combination of airborne, commercial and FIA in a region like Kosovo or North Korea or something like that, we still will be stressed to get all the information to support what people can properly use to make wise decisions.[19]

One other assumption that is critical to a CRIF is that commercial satellite imagery is able to fill valid imagery requirements in peacetime (non-surge requirements). In order for the CRIF to work, commercial imagery must fill valid requirements that will provide a sustainable level of government business that can be used as monetary incentive for vendor's participation in the CRIF. The CIS and two other studies validated this assumption that commercial imagery of one-to ten-meter resolution can accomplish many militarily significant tasks.[20]

Figure 2 is offered as visual evidence of the capability of these commercial systems. This image is from the first publicly released image from Space Imaging's IKONOS system and shows the general aviation ramp of Reagan National Airport in Washington, DC at better than 1m resolution. In comparison, the first Corona satellites provided 11m resolution and the last Corona satellites (1967-1972) had resolution somewhat better than 2m. The current IKONOS imagery is roughly twice as good (in terms of resolution) than reconnaissance systems the US used for the first 12 years.[21] Whether IKONOS imagery is good enough for high-accuracy targeting remains to be seen, but from the detail shown here it is obvious that it can be used for a variety of important intelligence tasks.[22]

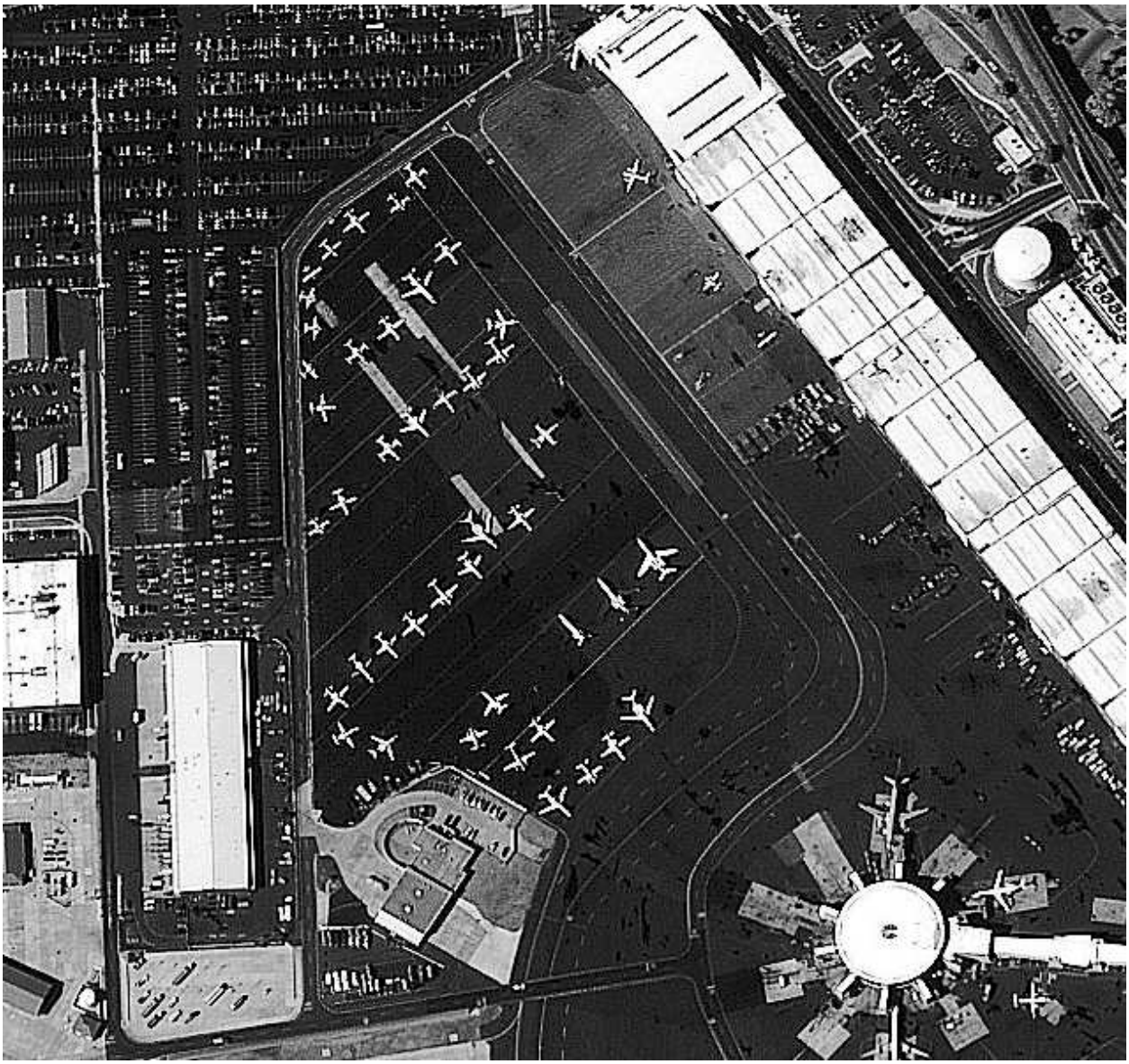

Figure 2 First IKONOS Image (Courtesy of Space Imaging)

Notes

[1] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 22. (SECRET/SCI/PROPIN) Information extracted is unclassified. NIMA's CINF is the intelligence community's projection of future imagery requirements. It is the most complete database available to study future imagery needs. However, the study stated explicitly one of its analysis assumptions: "NIMA's CINF database of requirements is a real reflection of government requirements in the future; although, a variety of non-CINF specified requirements are addressed."

Notes

[2] *Intelligence Authorization Act for Fiscal Year 2000*, Public Law 106-120, 106th Cong., (2000), comments on Section 701.

[3] Commercial Imagery Program, National Imagery and Mapping Agency, *Frequently Asked Questions, NIMA Use of Commercial Imagery* (October 15,1999).

[4] Ronald N. Priddy, *A History of the Civil Reserve Air Fleet In Operations DESERT SHIELD, DESERT STORM, and DESERT SORTIE*, (DOD Policy Board on Federal Aviation, Volpe National Transportation Systems Center), 1.

[5] Lt Col. Carl R. Behrens, "The Civil Reserve Air Fleet: The Past, First Use, and the Future," Air War College Student Report, US Air Force, (Maxwell AFB, AL: Air University Library, April 1994), 6.

[6] Priddy, 1.

[7] Ibid, 3.

[8] Ibid 4.

[9] Maj. Kirk L. Brown, "History of the Civil Reserve Air Fleet (1952-1986)," Air Command and Staff College Student Report, US Air Force, (Maxwell AFB, AL: Air University Library, April 1987), 3-28.

[10] Kevin C. Ruffner, ed., *CORONA: America's First Satellite Program*, CIA Cold War Series, (Washington, DC: History Staff, Center for the Study of Intelligence, Central Intelligence Agency, 1995), 37.

[11] George J. Tahu, John C. Baker, and Kevin M. O'Connel, "Expanding Global Access to Civilian and Commercial Remote Sensing Data: Implications and Policy Issues," *Space Policy* 14, no. 3 (Aug 1998), 180. See also Joseph C. Anselmo, "Commercial Space's Sharp New Image," *Aviation Week & Space Technology* (Washington, 31 January 2000), 56.

[12] Thomas A. Keaney, and Eliot A. Cohen, *Gulf War Air Power Survey. Summary Report*, (Washington, D.C.: United States, Department of the Air Force, 1993), 135.

[13] George J. Tahu, John C. Baker, and Kevin M. O'Connel, "Expanding Global Access to Civilian and Commercial Remote Sensing Data: Implications and Policy Issues," *Space Policy* 14, no. 3 (Aug 1998), 180.

[14] National Science and Technology Council, The White House, *FACT SHEET, NATIONAL SPACE POLICY* (September 19, 1996), 9.

[15] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 6-7 and 18-9. (SECRET/SCI/PROPIN) Information extracted is unclassified.

[16] Thomas A. Keaney, and Eliot A. Cohen, *Gulf War Air Power Survey. Summary Report*, (Washington, D.C.: United States, Department of the Air Force, 1993), 135. See also Keith Hall, "Media Roundtable Transcript," Director NRO, 8 July, 1999.

[17] Keith R. Hall, "The National Reconnaissance Office: Revolutionizing Global Reconnaissance," *Defense Intelligence Journal* 8, no. 1 (Summer 1999), 11. See also Keith R. Hall, "The National Reconnaissance Office - Freedom's Sentinel in Space," To be published in American Intelligence Journal, 1999, 23-4.

[18] Commercial Imagery Program, National Imagery and Mapping Agency, *Frequently Asked Questions, NIMA Use of Commercial Imagery* (October 15,1999). See also *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 43. (SECRET/SCI/PROPIN) Information extracted is unclassified.

Notes

[19] Keith Hall, "Media Roundtable Transcript," Director NRO, 8 July, 1999.

[20] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 43. (SECRET/SCI/PROPIN) Information extracted is unclassified. See also Lt Col. Larry K. Grundhauser, "Sentinels Rising," *Airpower Journal* 12, no. 4 (Winter 1998), 63-6. This reference talks about two studies performed by US Space Command and the Carnegie Endowment for International Peace that validate that commercial imagery of one- to ten-meter resolution can be used for many militarily significant tasks. Many of these tasks are not time-sensitive and the potentially slower delivery time of commercial satellite imagery is not an issue.

[21] Kevin C. Ruffner, ed., *CORONA: America's First Satellite Program*, CIA Cold War Series, (Washington, DC: History Staff, Center for the Study of Intelligence, Central Intelligence Agency, 1995), 37.

[22] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 43. (SECRET/SCI/PROPIN) Information extracted is unclassified. See also Lt Col. Larry K. Grundhauser, "Sentinels Rising," *Airpower Journal* 12, no. 4 (Winter 1998), 63-6. This reference talks about two studies performed by US Space Command and the Carnegie Endowment for International Peace that validate that commercial imagery of one- to ten-meter resolution can be used for many militarily significant tasks. Many of these tasks are not time-sensitive and the potentially slower delivery time of commercial satellite imagery is not an issue.

Part 3

Conditions for CRIF Implementation

> *[T]he government should rely on the commercial sector for the products and services it needs…[The Secretary of Defense shall] establish criteria for determining when government performance of a commercial activity is required for national defense reasons.*
>
> — US Bureau of Budget, 1955

Although the preceding evidence supports a CRIF concept to meet national surge imagery requirements, it is not clear that current government and industry conditions are sufficient to support the establishment of a CRIF. This section briefly reviews the status of the aviation industry preceding and during the CRAF formation to examine the conditions that precipitated the CRAF's formation. Using this analysis, the conditions necessary for the implementation of the CRIF are then explored. First, the legal basis for providing incentives to the industry for participation is examined. Second, establishing the exact requirement for surge capacity is discussed.

Legal Basis and Incentives to Vendors for Participation

Based on the successes of civil aviation during WWII and the Berlin Airlift, President Truman signed EO 10219 in March 1951 to create the CRAF. By this time commercial air service had truly become a national asset.[1] A major bolstering of the CRAF came several years later. The Federal Aviation Act of 1958 established the Federal Aviation Agency and required any carrier wishing to do business with the DOD to offer aircraft to the CRAF. This Act gave the

Secretary of the Air Force the legal basis for giving preferential treatment to CRAF participants for normal, peacetime airlift requirements.[2]

The main incentive for commercial airline participation in the CRAF, besides patriotism and utilization of excess airline capacity, is the lure of a sustained base of regular, peacetime airlift from the DOD. In the early 1960s the DOD commercial airlift budget amounted to approximately $150 million to $250 million per year.[3] By 1989, the airlift budget had grown to $618 million.[4] However, the drawdown of the military in the 1990s caused this budget to shrink and incentives diminished accordingly.

Likewise, the commercial satellite imagery vendors are interested in the same type of steady, baseline business. However, the government has not yet developed a commercial satellite imagery budget. NIMA's FY2000 budget for commercial imagery purchases is only $6.4 million. In addition, there is $75 million in the FY2000 budget for contractual production of geospatial data, products and services, some of which will be derived from commercial imagery. The jointly developed NIMA and NRO Commercial Imagery Strategy proposed a six-year (FY2000-2005) budget that would amount to nearly $1 billion. This would be broken down into approximately $320 million for commercial imagery purchases, $580 million for contracted geospatial data products and services, and $100 million for infrastructure improvements to better integrate commercial imagery into the government architecture.[5] But until this proposed budget becomes a reality, there is no financial incentive for the vendors to participate in a CRIF.

One possible solution is to aggregate the entire US government's requirement for commercial imagery into a single incentive pool. Currently at least two other government agencies—the National Air and Space Agency (NASA) and US Geological Service (USGS)—purchase commercial imagery for their purposes.[6] If the money dedicated for these purchases

could be pooled it would make a larger incentive for CRIF participation. This pooling could be accomplished by legislative action, similar to the Federal Aviation Act of 1958 that mandated airline participation in the CRAF prior to receiving any peacetime DOD airlift contracts. In the same manner, legislation could be put in place to require CRIF participation for any company providing imagery, or even imagery services to the US government.

Two other issues may affect the potential incentive pool for commercial imagery. The first is the NRO's Future Imagery Architecture. FIA will produce a government imagery system that is more capable than today's constellation, potentially leading to a decreased need for commercial imagery, even though commercial imagery will be integrated into FIA.[7] The commercial remote sensing companies argue that this is the wrong causal relationship, that FIA should be modified by the success of the commercial ventures.[8] However the FIA development train has already left the station and will not likely be impacted by commercial imagery, at least in the near-term. This trend toward decreased need for commercial imagery based on FIA capability may be countered by the second issue, the military's increasing reliance on information and information systems and an exponential need for imagery and imagery products.[9] Which of these trends will dominate remains an open question.

Requirement for Surge Capacity

The second condition that must be established prior to the formation of a CRIF is to understand the requirement for surge capacity. For the CRAF this was an ongoing argument between the commercial carriers and the military that was finally settled in 1960. The Defense Department published a report, approved by the President, entitled *The Role of Military Air Transport Service in Peace and War*. This report essentially established the size of the military airlift component by mandating that the military build indigenous airlift sufficient to meet "hard-

core" military requirements: outsize and oversize cargo, hazardous materials, and short take-off and landings from unimproved runways. The military could operate this airlift in peacetime to perform routine airlift, but all other airlift requirements would be reserved for US commercial carriers.[10] This eventually led to the situation prior to the Gulf War where commercial carriers had dedicated the capability to lift 17 million ton miles (MTM) per day of cargo to augment military airlift capability for a major theater war.[11]

Likewise, the US government needs to define more clearly the surge imagery requirements for crisis. This is necessary so that the incentive system can be set up to balance supply and demand. The actual surge requirements need to be explored in detail so the vendors offer what is needed. For example, in CRAF there are categories of capabilities (called segments) that are offered: long-range and short-range, cargo and passenger. These stages are based on the main requirement for long-range cargo capacity. Accordingly, the CRAF was set-up to give more credit to those companies contributing long-range cargo aircraft. Similarly, the exact surge requirements for a CRIF need to be defined so participation can be measured appropriately. In the CRIF some example requirement categories might be time-dominant vs. non-time-dominant, highest resolution vs. lower resolution, broad area vs. point targets, and panchromatic vs. multi-spectral just to name a few. This could also be where services other than collection capacity might be considered. During a crisis, there may be a requirement for surge exploitation or value-added product production capabilities. With some creative thinking, the CRIF might be used to help augment all phases of the imagery intelligence cycle including tasking, processing, exploitation and dissemination. Further refinement of these requirements is a necessary prerequisite to the successful creation of a CRIF. However, the detailed exploration of these requirements is beyond the scope of this study.

Notes

[1] Lt Col. Carl R. Behrens, "The Civil Reserve Air Fleet: The Past, First Use, and the Future," Air War College Student Report, US Air Force, (Maxwell AFB, AL: Air University Library, April 1994), 4.

[2] Ronald N. Priddy, *A History of the Civil Reserve Air Fleet In Operations DESERT SHIELD, DESERT STORM, and DESERT SORTIE*, (DOD Policy Board on Federal Aviation, Volpe National Transportation Systems Center),, 23.

[3] Priddy, 29.

[4] Behrens, 12. All figures are in then-year dollars.

[5] Commercial Imagery Program, National Imagery and Mapping Agency, *Frequently Asked Questions, NIMA Use of Commercial Imagery* (October 15,1999).

[6] Laura Robinson, Chief, NIMA Commercial Imagery Program, interviewed by author, Bethesda, MD, 16 March 2000.

[7] National Reconnaissance Office, "Press Release, NRO ANNOUNCES FIA CONTRACT WINNER," 3 September 1999, n.p.; on-line, Internet, 12 February 2000, available from http://www.nro.mil/PressReleases/prs_rel32.html. See also Raytheon Media Relations, "Raytheon Awarded Subcontract on National Reconnaissance Office Future Imagery Architecture Program," 31 August 1999, n.p.; on-line, Internet, 20 March 2000, available from http://www.raytheonsemi.com/press/1999/sep/fia.html.

[8] Jeff Kerridge, Vice President, Sales, EarthWatch, interviewed by author, Longmont, CO, 31 January, 2000.

[9] Thomas A. Keaney, and Eliot A. Cohen, *Gulf War Air Power Survey. Summary Report*, (Washington, D.C.: United States, Department of the Air Force, 1993), 135.

[10] Priddy, 25.

[11] Ibid, 34.

Part 4

Developing a Working Commercial Reserve Imagery Fleet

> *Intense efforts are under way to overcome the very daunting task of cheap, on-demand access to space—a task that is orders of magnitude more complex and fundamentally different than that which allowed access to the skies.*
>
> — Maj Bruce M. DeBlois

Having established the need for a CRIF and the necessary conditions for implementing it, this section concentrates on the details of setting up a CRIF. An analysis of the CRAF provides a useful baseline from which to start. The details of the commercial satellite imagery industry are compared to the airline industry to identify significant differences. A CRIF structure is then proposed based on this analysis.

Conceptual Framework for Analysis

This section discusses three major areas for implementing a CRIF. The first is establishing the legal framework for a CRIF. Commercial companies are compelled to act by entering into contractual arrangements with the government. Correspondingly, the CRIF should be comprised of a series of contracts detailing how the satellite imagery companies (hereinafter vendors) will participate when the CRIF is activated. This section covers how the CRIF contracts might be structured to meet national security objectives while accounting for the unique aspects of the satellite imagery business. Important issues of how vendors participate in the CRIF, how it is called up and the incentives for participation will be discussed. The second section discusses

organizational and manpower issues for the proper administration of a CRIF. Again, the CRAF is instructive for examining the organizational elements that might be necessary to control a CRIF. Finally, the third section addresses a series of issues that must be considered for a robust CRIF system including physical risks, financial risks and security issues. The CRAF provides a valuable baseline for analyzing what may or may not work in these areas.

Contractual Model

Like the CRAF, the CRIF should be implemented as a series of contracts. The contracts provide the vehicle to pay for the commercial companies' participation when the CRIF is activated. The contracts have several important points that need to be examined and developed. First is how the commercial companies' participation is measured. In the CRAF, greater participation gives greater preference for peacetime airlift contracts. Similarly in the CRIF, a way to measure vendors' participation is necessary to allocate rewards in the CRIF incentive system. Second, the CRAF contract established a series of stages and segments for airline activation to give the government maximum flexibility in meeting its needs. A similar system of segments and stages is discussed for the CRIF. Finally, problems with airlift logistics lead to a discussion of getting imagery and imagery information to the end user before the surge requirement is fulfilled. These items are analyzed in light of the unique aspects of the commercial satellite imagery industry.

Measuring Vendor Participation

In the CRAF model, airlines voluntarily designate a certain number of aircraft for participation. Some aircraft are more valuable than others because of characteristics such as longer range or more cargo capacity. The vendor is given more "credit" for allocating aircraft

with these desirable characteristics by calculation of the aircraft's Mobilization Value (MV). A MV is calculated for each aircraft allocated to the CRAF based on its payload capacity, volume, speed, and range. The sum of all the MV of a carrier is computed and the airlines with the largest sums get the greatest percentage of DOD peacetime airlift contracts.[1] (For a detailed look at how MV is calculated see Appendix A.)

While a concept similar to MV might be developed for imaging spacecraft, the concept of exclusive use is not the same. Aircraft are mobile and can be moved to where they are needed. But an aircraft being used on a CRAF mission is not available to be used by the commercial carrier. However, a satellite taking images in support of the CRIF remains available to the vendor and the image itself could be re-used by the vendor, if allowed.[2]

So an imagery satellite itself is clearly not the equivalent unit to an aircraft in the CRAF. The satellite imagery business does not have such a clearly defined and easily fungible unit of measure. The three vendors generally speak in terms of images, equivalent images[3] or seconds of imaging time. They sometimes talk in larger terms about percentage of collection capacity. Additionally, these terms all have a geographic fixation. That is to say they are tied to the satellite location at the time. Capacity, images or seconds of imagery time in one geographic region have very little or no impact for a different region.[4]

Compounding this issue, crises tend to be geographically confined, although the exact location is difficult to predict in advance. For CRAF activation this is not a particularly difficult issue since aircraft have the flexibility to move to the location. For imagery vendors this is more difficult for two reasons. First, each vendor has a different business model. All the companies have signed up partners around the world; however, the relationship between the vendor and the partners and the rights of the partners varies significantly from vendor to vendor. Thus the ability

of individual vendors to commit capacity to a CRIF may vary.[5] Second, even within a single vendor, the geographic distribution of partners and the amount of total capacity over specific regions committed to these partners vary dramatically.[6] This increases the difficulty in developing a general scheme that allows vendors to "participate" in a globally applicable CRIF, at least initially. Over time, this situation may resolve itself as a standard business practice emerges.

Based on these concerns and information provided by the vendors, the best unit of measure for the CRIF is seconds of imagery time per day, based on its universality and ease of measurement. The value of these seconds may be determined by the following attributes: swath width, equivalent image size, and delivery time. Additionally, a quality measure (that will be discussed under Segments below) should contribute to the value, as well as the priority of tasking and the geographic concentration allowed. Geographic concentration refers to how densely the seconds may be tasked. For example, if a vendor offers 100 imaging seconds per day, the government may place a higher value on this time if all 100 seconds can be collected over a single region. Alternatively, the vendor may offer 100 seconds per day with no more than 50 seconds collected in one pass. This may be of lower value to the government. The exact weighting system will need further study, based on government requirements.

Segments

The CRAF model breaks up participation into segments to maximize flexibility in activation and to better define the specific needs of the government for various levels of crisis. The CRAF has five segments, each with specific requirements: long-range international, short-range international, domestic, Alaskan, and aeromedical evacuation. Each of these segments is designed to address a specific airlift shortfall that may occur during a crisis.[7] For example, long-

range international aircraft must have extended overwater capability with the necessary navigation, communication and survival equipment to fly at least 2350 nautical miles with a productive load. Additionally, the segments are further subdivided into two sub-categories—cargo aircraft and passenger aircraft—since the two types of airlift capabilities address separate needs and cannot be easily interchanged.[8]

Similarly, the CRIF may benefit from having pre-defined segments. The proposed segments are High-resolution Point Collection, High-resolution Area Collection, and Broad Area Coverage. These terms have generally accepted meaning within the Intelligence Community and divide the requirement set into recognizable areas. The exact resolution limits and coverage capabilities of these segments still need to be determined.. For example, the high-resolution point collection segment will have a minimum quality (lowest acceptable resolution), image size and timeliness requirement associated with it that will correspond with being able to complete certain intelligence tasks. These segments can be further categorized by sensor type. In this case the categories will be Panchromatic and Multi-spectral. If the CRIF were expanded to foreign systems or a US radar satellite was developed, a Radar category might also be useful. The exact requirements for each segment need to be resolved by a thorough study.

Continuing with the example from the vendor participation section above, a vendor might participate in the CRIF by offering 100 imaging seconds per day in the High-resolution Point Collection Segment and 200 seconds per day in the Broad Area Coverage Segment. Orbital mechanics may preclude a vendor from having any imaging seconds that meet high-resolution standards on a given day, but this is a known fact-of-life in the satellite imagery business. This construct allows the government some level of predictability of access required during a crisis, yet acknowledges access limitations inherent in the satellite business.

Stages

The CRAF model has three call-up stages to provide maximum responsiveness and flexibility: Stage 1—Committed Expansion, Stage 2—Defense Airlift Emergency, and Stage 3—National Emergency. The commander of Air Mobility Command can activate Stage 1, while Stages 2 and 3 require the National Command Authority (President or Secretary of Defense) for activation. In addition, each call-up stage is comprised of different segments of the CRAF to meet the requirements of that level of crisis. As seen in Table 1, Stage 1 is comprised only of long-range international segment aircraft, while the other two stages include all the other segments except aeromedical, which is only in Stage 3.[9] The number of stages required for a CRIF will probably mirror this three-level approach. However, the number of stages needed and the exact composition of the segments within any stage is a subject for further investigation, based on the requirements of the government.

Table 1 Number of Participating Aircraft by CRAF Stage and Segment in 1990[10]

Segments	Stage 1 Committed Expansion		Stage 2 Defense Emergency		Stage 3 National Emergency	
	Cargo	Pax[11]	Cargo	Pax	Cargo	Pax
Long-range International	21	17	38	75	135	250
Short-range International			2	21	6	28
Domestic			44		44	
Alaskan			2		2	
Aeromedical Evacuation						31

A notional stage, segment and category breakdown for the CRIF is given in Table 2.

Table 2 Notional CRIF Stages, Segments and Categories

Segments	Stage 1 Committed Expansion		Stage 2 Defense Emergency		Stage 3 National Emergency	
	Pan	MS	Pan	MS	Pan	MS
High-resolution Points						
High-resolution Area						
Broad Area Coverage						

Logistics: Processing, Production and Dissemination

During the CRAF call-up for Desert Storm, several logistics and planning problems were unexpectedly encountered. First was a lack of loading and unloading equipment for the commercial aircraft that caused longer ramp times for the aircraft than planned for. Additionally, wide-body passenger aircraft modified to carry cargo under the CRAF Enhancement Program[12] had no provision for using loading equipment and had to be loaded and unloaded by hand. So even though they could carry more cargo, the long delays made them less useful. Also, commercial carriers were not well prepared to handle or transport hazardous materials.[13] These examples indicate a thorough examination of the details of getting the product to the end user must be made in order to have a successful surge capacity. Just increasing the number of ton-miles per day that can be carried is not sufficient to improve overall capability.

Likewise for the CRIF, just having the collection capacity to meet surge requirements does not completely meet the end user's need. His need is not met until the product is in his hand. In the intelligence community, this is referred to as completing the intelligence cycle. As shown in Figure 3, collection is only one part of the cycle that delivers the final product to the user. The planning and direction portion of the CRIF will be discussed later in the section on organization.

This section will briefly discuss the processing, production and dissemination portion of the intelligence cycle.

Figure 3 Joint Intelligence Cycle[14]

Processing commercial imagery is a normal function of the commercial vendors to turn raw data from the satellite into useable information: images. The vendors' systems are sized to process all of the data from their satellites, so surge processing capacity is not an issue. However, one scheme for improving the delivery of image data to the user is to downlink the imagery directly to the theater. In fact, the three vendor systems are all designed to operate primarily in a direct downlink mode. In this case, the government needs to develop an in theater, direct downlink processing system, similar to the US Air Force and US Army Eagle Vision systems.[15]

Once processing is complete, production entails the integration, evaluation, analysis and interpretation of information, in this case commercial imagery, to produce finished intelligence.[16] This implies that in order to generate a true surge capacity, not just for imagery collection, but

also intelligence production, surge analysis and exploitation capability must be developed as well. Just like the CRAF concept, which has a separate contract for logistics to support surge commercial airlift capacity, the CRIF should have a separate contract for exploitation and value-added product support for surge commercial imagery collection capacity. This may take one of two forms. The contract could be set-up as a separate logistic-type contract as a separate part of the CRIF. Or the concept may be to add an additional segment to the existing CRIF contract, to "back-fill" domestic exploitation and value-added product production requirements as government analysts and production resources are switched over to work on the crisis. This "back-fill" concept would then work similarly to the CRAF Domestic segment to augment the domestic requirements that are not being met as military airlift aircraft are called into service to support the crisis.

Finally, the image or finished intelligence must be transmitted to the user. This is the dissemination phase. Dissemination of surge commercial imagery as part of CRIF will likely be over the same dissemination paths for normal, non-surge imagery.[17] The design of the dissemination system only needs to take into account the surge rates expected. These rates will come from the detailed requirements analysis that still needs to be conducted.

At the appropriate time, all these logistics considerations need to be folded into the government imagery system architecture, known as the US Imagery and Geospatial Information Service (USIGS).[18] Ideally commercial imagery providers would integrate seamlessly into the system so that they look and feel like government imagery providers (the NRO and other tactical imagery systems). Without a comparable level of integration, the commercial systems will not be able to fulfill their full capability to meet established requirements. Several infrastructure improvements could be looked at to meet near-term and future needs. These include, but are not

limited to improved electronic delivery, improved visibility into tasking and collection status, common countdown of requirements, direct downlink of imagery to theater, and near real-time downlink of imagery.[19]

CRIF Organizational Structure

After many changes and organizational evolutions, the current CRAF organizational structure is relatively solid. It provides a good baseline for administration and operation of a CRIF. In fact, a similar organizational construct is already in place.

At the top level, the CRAF has functional control split between the Department of Defense and the Department of Transportation. After years of evolution, in May 1981 a Memorandum of Understanding (MOU) between the DOD and DOT redefined the relationship between the two departments with CRAF allocation assigned to DOT and CRAF operation assigned to DOD.[20]

A similar structure exists today for commercial satellite imagery. Licensing authority and regulation of the commercial remote sensing industry is given to the Department of Commerce (DOC) by the Land Remote Sensing Act of 1992.[21] Thus, if a CRIF is implemented, it will likely entail a similar MOU between the Department of Commerce for allocation authority and the IC/DOD for the operation.

For the day-to-day and emergency operation of the CRIF within the intelligence community, the CRAF model is also highly instructive. The DOD organization that controls the CRAF is the Air Force Air Mobility Command (AMC). The portion of the organizational structure relevant to the CRAF is shown in Figure 4. Day-to-day administration of the contracts and operational control flows from AMC headquarters through the Director of Operations to the Contract Airlift Division. The Airlift Procurement Branch manages the contracts for international segments and domestic segments in two separate sections.[22] During a crisis, an AMC crisis action team (CAT)

is formed with representatives from all the necessary AMC staff agencies. Within the CAT is a CRAF Cell composed of military members directly responsible for the operational management of the CRAF. The last barrier to overcome is the interface with the commercial carriers. Each commercial carrier uses its own method of scheduling, has its own cargo tracking system, and is different from those systems used by the military. To handle this diverse industry and ensure interface with military operations the CRAF cell has a Technical Advisory Group (TAG). The TAG is made up of "qualified airline representatives designated and provided by CRAF carriers that will furnish technical advice and information designed to provide maximum coordination, efficiency, and effectiveness in the use of the CRAF." The TAG may operate during peacetime and during CRAF activation.[23]

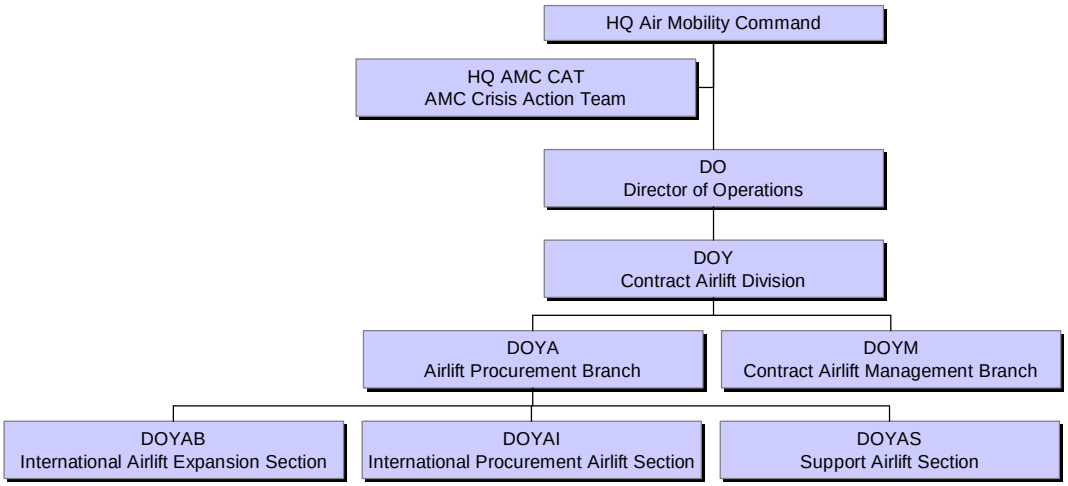

Figure 4 HQ AMC Organization for CRAF Implementation and Operation

A similar organizational structure for commercial imagery also exists within the National Imagery and Mapping Agency. DOD Directive 5105.60 gives NIMA the authority to contract for, order and purchase commercial imagery for the DOD, IC and other organizations, as appropriate.[24] Figure 5 shows the organizational structure within NIMA that is currently set-up for this function. The NIMA Commercial Imagery Program (CIP) is part of the Central Imagery Tasking Office (CITO) within NIMA's Operations Directorate.[25] The CIP negotiates and

manages the day-to-day contract operations for commercial satellite imagery. The CIP would be the logical place to negotiate and manage CRIF contracts, as well. CITO is also establishing a Commercial Imagery Staff Office (CISO) that is designed to interface commercial requirements with the national Requirements Management System (RMS). Thus CISO will be the responsible office for deconflicting national and commercial imagery collection on a routine basis.[26] A crisis action team or CRIF cell could be attached to the CISO or be formed at a higher level within the NIMA operations chain to handle surge imagery requirements during crisis. Additionally, an imagery vendor TAG within this cell may be useful to smooth any interface issues.

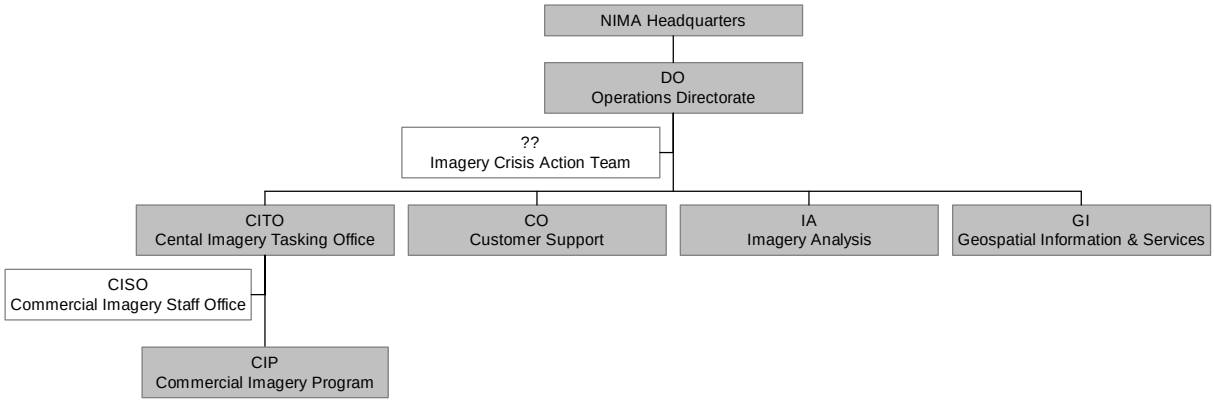

Figure 5 NIMA Commercial Imagery Organization

Vendor Issues for CRIF Participation

Finally, there are a several other issues that surround the CRAF that are instructional in the development of a CRIF. The issues fall into three broad categories: financial impacts, physical risks, and security.

Financial Impacts

In the CRAF, there are two issues related to financial impacts of CRAF participation that are relevant to the development of the CRIF. The first is the current business environment. The airlines are very mature and operate under the rules of deregulation. This affects the way they

participate. Second, the aviation industry has worked its way through a period where they were concerned about competition from military airlift for the lucrative business of moving military equipment and personnel. This same competition for military imagery business is a major issue for the imagery vendors.

Vendor Business Environment Implications. Under deregulation, the airlines are constantly striving for increased efficiency and less overhead.[27] Correspondingly, they have lost the ability to absorb a CRAF call-up and are thus reluctant to participate for fear of losing market share. Long-term losses outweigh short-term gains.

Imagery vendors are not worried about deregulation, but the current business environment does affect their ability to participate in a CRIF. As was alluded to earlier, the three vendors have each established different business models regarding the rights and responsibilities of their investment partners. Thus, a particular vendor will find it easier or harder to participate in a CRIF depending on the contractual details. The details of the various business models are proprietary information and may not be specifically discussed. At this point, it must suffice to say that this concern must be taken into consideration during CRIF development.[28]

Government Competition. As the airlines developed, they constantly complained about the competition from the military airlift system and made political moves to obtain the bulk of military airlift for themselves.[29] This issue was studied extensively. Eventually the military agreed to develop airlift systems specifically designed to meet military "hard-core" requirements that could not be met by civilian aviation: oversized and outsized cargo; in-flight refueling capability for extended range; and the ability to land and take-off from short, unprepared runways. The maintenance of this capability would necessarily mean that some peacetime airlift would be done by the military, but the rest was to be given to commercial companies.[30] In 1956,

DOD Directive 5160.2 required military airlift to be re-established on an "industrial-fund basis", that is, military airlift had to be operated like a business with users paying for the airlift they need. The airlines however continued to complain that the competition was not fair because the amount charged by the military did not account for the costs of the equipment or the salaries of the operators as these items came out of a different pot of money.[31]

In the CRIF arena, one method for improving competition between government and commercial collection systems might be to re-establish the government imagery business on an industrial-fund basis as was done for airlift in the 1960s. This would entail the government establishing a practice where the imagery customer spay for imagery and imagery services from the government imaging system, just as they pay for commercial imagery and services. However, this may be difficult to accomplish based on the current National Space Policy. This policy states that the price charged for government facilities, equipment or service "will not seek to recover the design and development costs of investments associated with any existing or new facilities required to meet U.S. government needs and to which the U.S. government retains title."[32]

Physical Impacts

The threat of SCUD missile attacks with chemical weapons made protection of assets and people a key issue for the CRAF during the Gulf War. The government issued chemical gear to the aircrews, but a lack of training and unwillingness to use the equipment caused those precautions to be of little use.[33] Additionally, commercial insurers cancelled insurance on aircraft called into the CRAF.[34] Congress had previously addressed this issue in 1951 by adding a Title XIII to the Civil Aeronautics Act of 1938, allowing the DOC to provide aviation war risk insurance during crises.[35]

If US commercial imagery vendors were to be activated under a CRIF, it could increase the likelihood of attack on their assets, both terrestrial and space-based. Due consideration must be given to this possibility to include protection and training against possible attacks, conducting vulnerability assessments and setting up passive and active defense measures. Further research investigating the implications of CRIF activation on the ability of the vendors to insure their assets must be completed. It may be necessary to legislate a government insurance program for times of crisis, similar to the Title XIII insurance for aircraft.

Secure Communications and Classified Data Handling.

During CRAF activation for Desert Shield, there were little or no common communications systems or procedures and no provision for secure communications—something necessary for military operations. Additionally, the mission requirements were classified and the carriers had no provision to receive or carry classified operations plans. This situation eventually led to a compromise as commercial aircrews routinely ignored the onerous and hastily prepared procedures for handling classified information.[36]

Based on the experience of CRAF activation during the Gulf War, it is necessary for government operations to have the capability to handle secure communications and store classified data related to the assigned missions. Efforts are currently under way to improve each of the vendor's capabilities in this area.

Notes

[1] Ronald N. Priddy, *A History of the Civil Reserve Air Fleet In Operations DESERT SHIELD, DESERT STORM, and DESERT SORTIE*, (DOD Policy Board on Federal Aviation, Volpe National Transportation Systems Center), 26.

[2] Synthesis of information from three vendor interviews: Joseph Dodd, Vice President, Government Programs, ORBIMAGE, interviewed by author, Dulles, VA, 24 January 2000; Gary Fuller, Director, Development Programs, Space Imaging, interviewed by author, Tysons Corner,

Notes

VA, 24 January 2000; and Jeff Kerridge, Vice President, Sales, EarthWatch, interviewed by author, Longmont, CO, 31 January, 2000.

[3] An equivalent image is usually the smallest image the system can take. The amount of system resources consumed is sometimes measured by comparing the actual image size as it is taken to the number of equivalent images that could have been taken in the same time. As a simplified example, if the smallest image size a particular system produces is 10x10km, an image that is 10x30km in size is three equivalent images in size and is priced at three times the equivalent image rate.

[4] Synthesis of information from three vendor interviews. See also *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 37-8. (SECRET/SCI/PROPIN) Information extracted is unclassified. "Global collection capability is difficult to quantify as the distribution of targets globally can have a significant effect on collection performance…regionally, commercial architectures are limited by access and slow imaging times."

[5] Ibid.

[6] Ibid.

[7] Maj. Kirk L. Brown, "History of the Civil Reserve Air Fleet (1952-1986)," Air Command and Staff College Student Report, US Air Force, (Maxwell AFB, AL: Air University Library, April 1987), 28-9.

[8] Air Mobility Command Regulation (AMCR) 55-8, *Operations, Civil Reserve Air Fleet (CRAF)* (Headquarters Air Mobility Command, Department of the Air Force, 15 August 1992), 11-12. Detailed minimum requirements for each segment and aircraft type—cargo and passenger—are contained in this regulation in Chapter 2, Sections E and F.

[9] Brown, 28-9.

[10] Priddy, D-1 through D-4. The number of aircraft in each stage are cumulative (e.g. the 250 Long-range International passenger aircraft in Stage 3 include the 75 aircraft from Stage 2 which includes the 17 aircraft from Stage 1).

[11] passenger aircraft

[12] William G. Palmby, *Enhancement of the Civil Reserve Air Fleet: An Alternative for Bridging the Airlift Gap*, (School of Advanced Airpower Studies, Maxwell Air Force Base, Alabama, June 1995), 25. The CRAF Enhancement program started in 1979 to modify existing or new aircraft to better carry cargo. Aircraft committed to the CRAF by the airlines are primarily passenger aircraft with limited cargo capacity, especially for oversized or outsized cargo. DOD's primary surge need is for cargo capacity, not moving troops. To overcome this problem, Air Mobility Command (AMC) proposed to modify existing or new aircraft in production to add a cargo door and beef-up the flooring system so that a passenger aircraft can be quickly converted to a cargo aircraft. This issue was studied extensively and was found to be the most cost-effective way to increase the surge cargo capacity for the nation, better than a similar amount of organic capability either through new military systems or buying new commercial aircraft for dedicated military use.

[13] Lt Col. Carl R. Behrens, "The Civil Reserve Air Fleet: The Past, First Use, and the Future," Air War College Student Report, US Air Force, (Maxwell AFB, AL: Air University Library, April 1994), 17.

Notes

[14] Joint Pub 2-0, *Doctrine for Intelligence Support to Joint Operations,* (Joint Staff, Department of Defense, 1995), II-3.

[15] Pat Riggs, "EVII System Description," US Army Topographic Engineering Center, 26 January 1999, n.p.; on-line, Internet, 20 March 2000, available from http://www.tec.army.mil/Ev_II/sysover.htm.

[16] Joint Pub 2-0, II-5.

[17] Commercial Imagery Program, National Imagery and Mapping Agency, *Interim Demonstration Test Report FY99: CONUS/Hawaii Commands and Organizations,* (30 November 1999), 5.

[18] EarthWatch, ORBIMAGE, Space Imaging, "Point Paper for Commercial Imagery Industry Meeting with Congressional Staff," (joint industry unpublished point paper, 7 January 2000).

[19] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U),* 15 July 1999, 48. (SECRET/SCI/PROPIN) Information extracted is unclassified. The report's recommended "Cooperative Engagement Strategy" is based on a "pay as you go" integration of current commercial imagery, imagery products and services. The potential elements for government industry interaction include several options. First, spin-offs of unique government imaging or communications technologies for commercial use (e.g. government high-fidelity geo-location accuracy used on commercial multi-spectral products). Second, defense related procurement "pull" (e.g. near-real-time downlink). Third, concurrent development (hyperspectral technology). Fourth, shared infrastructure for tasking and requirements management. Fifth, dual-use technology (government "hardening" of critical satellite components). Last, spin-on of commercial standards for direct government purchase and use. This strategy looks at high near-term costs producing even larger savings in the future.

[20] Ibid, 30.

[21] *Land Remote Sensing Policy Act of 1992,* Public Law 102-555, 102nd Cong., 2nd sess., (28 October 1992).

[22] Air Mobility Command, "Welcome to Headquarters Air Mobility Command Contract Airlift Division," 9 November 1999, n.p.; on-line, Internet, 13 March 2000, available from http://www.amc.af.mil/do/DOY.htm.

[23] AMCR 55-8, 11.

[24] Commercial Imagery Program, National Imagery and Mapping Agency, *USIGS Commercial Satellite Imagery Concept of Operations,* (July 1999), (For Official Use Only), 4.

[25] National Imagery and Mapping Agency, "WWW Organizational Chart," June 1999, n.p.; on-line, Internet, 13 March 2000, available from http://164.214.2.59/org/ orgchart.html.

[26] Commercial Imagery Program, National Imagery and Mapping Agency, *USIGS Commercial Satellite Imagery Concept of Operations,* (July 1999), (For Official Use Only), 4.

[27] Behrens, 20.

[28] Synthesis of information from three vendor interviews.

[29] Brown, 26.

[30] Priddy, 25.

[31] Ibid, 19-20.

[32] National Science and Technology Council, The White House, *FACT SHEET, NATIONAL SPACE POLICY* (September 19, 1996).

Notes

[33] Behrens, 16.
[34] Ibid, 18.
[35] Priddy, 202.
[36] Ibid, 89.

Part 5

Summary and Conclusions

> *Surveillance, reconnaissance, and knowledge of the precise location of dispersed friendly forces with the ability to direct their efforts are applicable for all military tasks.*
>
> — Joint Vision 2010

The inclusion of advanced technology in our military doctrine to improve our ability to find, fix and target anything with greater speed and accuracy is driving an ever-increasing requirement for imagery during crises. In response, the evidence presented in this paper supports the formation of a CRIF. The intent of Congress to support commercial imagery and control the cost for national imagery sources is clear.[1] Tough Congressional budget decisions will eventually refocus national imagery systems on the "hard core" requirements and commercial imagery will be relied upon to fill routine collection and supplement national systems for surge capacity during crisis. The historical parallel between commercial aviation and commercial satellite imagery illustrates a successful CRIF is likely and supportable. Additionally, preliminary studies validated the ability of commercial systems to fill baseline peacetime and surge imagery requirements.[2] The only remaining question is when a CRIF will become a viable option.

This study identified the two major conditions that must be met prior to the implementation of a CRIF. The first is the development of a viable incentive system. Commercial companies will not volunteer to participate in a CRIF if the incentives are lacking. Development of this incentive

system will likely take some time and be somewhat dependent on the viability of the commercial remote sensing industry. The government is making progress on establishing a workable incentive program through the development of a $1 billion peacetime program over six years. If this comes to fruition it would provide the necessary funding basis and a sufficient incentive. The second condition is for the government to examine in detail the surge requirement for commercial imagery. The government needs to have an understanding of the quantity, quality and timeliness of imagery necessary to meet surge crisis requirements. A good understanding of the requirements is necessary to balance the supply and demand equation of a CRIF.

Finally, the details of how a CRIF could be implemented were proposed. While the CRAF provides an excellent model to jump-start the CRIF development process, there are significant differences between the two industries that must be considered. The contractual model, organizational lessons and risks that arose during the CRAF's activation serve to refine CRIF implementation. Table 3 presents a summary of the similarities and differences between the two industries and the effects on CRIF formation. The biggest difference between the two industries is the state of maturity. By the time the CRAF was implemented in 1951, commercial air service was a robust industry that had proven itself in WWII and the Berlin Airlift. AMC is now struggling with maintaining the CRAF in the current environment of deregulation. Conversely, the satellite imagery business is working to establish its market position. This condition demands that the government fully understand its requirements before implementing a CRIF and work even harder to shape the incentive program appropriately.

The other primary difference is the basic unit of measure for participation. The CRAF uses number of aircraft. This analysis shows that the equivalent unit of participation for satellite imagery is seconds of imaging time. Using this measure, the CRAF model of stages, segments

and categories can then be adopted for CRIF with the appropriate elements redefined to meet the satellite imagery industry. From an organizational standpoint, control of the CRAF and control of satellite imagery have similar structures. If the CRAF serves as a good organizational example, a cell needs to be created in the NIMA Operations chain to coordinate and deconflict commercial imagery requirements during crises.

Table 3 Aircraft vs. Satellite Imagery Comparison

	Civil Aviation/CRAF	Satellite Imagery/CRIF
Current Business Environment	Deregulation, Competition	Establishing Market Position
Participation Incentive	Priority for Peacetime DOD Airlift	Peacetime Imagery Budget Does not yet exist
Participating entity	Company	Company
Resource	Airline Fleet	1 or 2 Satellites
Unit of Measure	Airplane	Seconds of Imagery Time
Segments	Long Range International Short Range International Domestic Alaskan Aeromedical Evacuation	High-resolution Points High-resolution Area Broad Area Coverage
Stages	I-Committed Expansion II-Defense Emergency III-National Emergency	Same
Categories	Cargo Passenger	Panchromatic Multi-spectral Radar (future)
Organization at Call-up	AMC Crisis Action Team	NIMA/CISO or NIMA CAT
Call-up Presumption	Keep Airlines Operating	Keep Vendors Operating
Risk to Companies' Assets for Participation	Physical and Financial	Physical and Financial

The requirement for a surge imagery capacity is valid. The Gulf War, recent conflicts, and the increasing need for information and speed in modern wars clarify this requirement. Plotting the recent actions of Congress against the historical example for airlift makes it equally clear that a CRIF is in the future. The only question is when. The government needs to work with industry

to establish the conditions that will support the national interest through the development of a robust commercial satellite imagery industry that will blossom into a national resource.

Notes

[1] *Intelligence Authorization Act for Fiscal Year 2000*, Public Law 106-120, 106th Cong., (2000), section 703 and notes on section 701.

[2] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 43. (SECRET/SCI/PROPIN) Information extracted is unclassified.

Part 6

Recommendations

> *Aerospace technology and industry is a national treasure and a competitive edge, militarily and commercially. Now, more than ever, we have the opportunity to mature the abilities of our air and space forces and make them even more useful tools for meeting our national security objectives.*
>
> — US Air Force's Global Reach - Global Power

It would not be possible to negotiate a CRIF today. As this study has pointed out, there are at least two necessary conditions that need to be met prior to implementing a CRIF. These are development of the incentive for participation and refinement of the surge requirements. Additionally, there are several interim steps that can be taken to enhance the utility of commercial imagery and accelerate the development of the CRIF. Each of these items will be discussed briefly below.

Suggested Courses of Action

The first step is to develop the incentive for participation. The industry has indicated that a commitment on the order of $50 million per year would be adequate to assure the vendors of sufficient business enabling them to invest in infrastructure and future system developments that meet an expanded set of government requirements.[1] Government budgets that would adequately meet the needs of industry have been proposed. The Commercial Imagery Strategy Study, approved by the Directors of NRO and NIMA, has put forward a budget that includes direct

imagery purchases averaging over $50 million per year over the FY00-05 budget cycle. Additionally, there is more money budgeted for infrastructure improvements and value added products and services.[2] The government needs to follow-through with these budgets and establish firm commitments to the industry. Without an established incentive of this magnitude, there is no reason a vendor would volunteer to participate in a CRIF.[3]

Second, one of the major assumptions for this study was that a surge requirement for imagery existed that could be fulfilled by commercial imagery. This assumption has been validated by a previous study[4], but the detailed requirement has not been established. This must occur before a CRIF can be implemented. In the CRAF example, the military figured out how much of an airlift deficit existed to support a major theater war.[5] The CRAF, although voluntary, could then be sized appropriately. Likewise the government needs to establish the quantity, quality and timeliness of its surge imagery requirements in some detail. Establishing the requirement will be the first step in developing the weighting system used to measure participation in the CRIF. More value will be given to participation that meets the most critical needs.

Finally, there are several steps the government can take now to speed and smooth the integration of commercial imagery into USIGS and improve the implementation of a CRIF when the time is right. The government needs to act now to influence the Future Imagery Architecture development so that commercial imagery providers are integrated seamlessly. Additionally, the government needs to firm up the organizational structure within NIMA that will be responsible for all commercial imagery activities.[6]

Areas for Further Study

Through the research for this paper there were many more topics than could be covered. The following bullets are offered as areas for further study:

- Foreign Satellite Vendor Participation in an Expanded CRIF
- Development of the Weighting System for measuring the value of CRIF participation
- Relationship between CRIF and the implementation of Shutter Control
- Using commercial satellite communications industry as a model for CRIF (instead of using CRAF as the model)[7]
- Future commercial imagery requirements: decreasing because of FIA or increasing because of demand?
- Viability of commercial remote sensing industry on CRIF implementation
- Development/Modification of Second Generation Satellite Systems and Infrastructure to improve satisfaction of government requirements

Notes

[1] Joseph Dodd, "Alternatives for Integrating Commercial High Resolution Imaging Satellites in the Future Architecture," (unpublished white paper, ORBIMAGE, Dulles, Virginia). Also discussed in vendor interviews: Joseph Dodd, Vice President, Government Programs, ORBIMAGE, interviewed by author, Dulles, VA, 24 January 2000; Gary Fuller, Director, Development Programs, Space Imaging, interviewed by author, Tysons Corner, VA, 24 January 2000; and Jeff Kerridge, Vice President, Sales, EarthWatch, interviewed by author, Longmont, CO, 31 January, 2000.

[2] National Imagery and Mapping Agency and National Reconnaissance Office, "Commercial Imagery Strategy," (Unpublished briefing slides, Chantilly, Virginia, July 1999), (FOUO).

[3] Joseph Dodd, "Alternatives for Integrating Commercial High Resolution Imaging Satellites in the Future Architecture," (unpublished white paper, ORBIMAGE, Dulles, Virginia).

[4] *NIMA & NRO, Commercial Imagery Strategy, Development Team Recommendation, Final Report (DRAFT) (U)*, 15 July 1999, 43. (SECRET/SCI/PROPIN) Information extracted is unclassified.

[5] William G. Palmby, *Enhancement of the Civil Reserve Air Fleet: An Alternative for Bridging the Airlift Gap*, (School of Advanced Airpower Studies, Maxwell Air Force Base, Alabama, June 1995), 1.

[6] EarthWatch, ORBIMAGE, Space Imaging, "Point Paper for Commercial Imagery Industry Meeting with Congressional Staff," (joint industry unpublished point paper, 7 January 2000).

[7] . Gary Fuller suggested that the commercial satellite communications industry is a better model to use for developing a CRIF. However, this idea is beyond the scope of this study. Gary Fuller, Director, Development Programs, Space Imaging, interviewed by author, Tysons Corner, VA, 24 January 2000.

Appendix A

CRAF Mobilization Value (MV) Calculation

General. The MV is a relative measure of the value DOD places on commercial aircraft for meeting wartime requirements.

Basic MV Computation Factors. The aircraft MV computation is based on aircraft payload, volume, block speed and range. Computation data is derived from the standard equipment and configuration of each aircraft.

- Payload is based on aircraft weight capability at a specified range.
- Volume is provided by the number of 463L pallets on the main deck and LD-3 containers in the lower lobe carried on board cargo aircraft.
- Block speed is computed in accordance with Air Force airlift planning directives using the average speed with 25 minutes added for taxi, takeoff, approach, landing, and block-in.
- Standard range for MV computations for each segment
    - Long-Range International and aeromedical 3500nm
    - Short-Range International 1500nm
    - Domestic 400nm
    - Alaskan 400nm

Long-Range International and Aeromedical Evacuation CRAF Computation/Factors and Procedures. Computations are based on the relative capability of long-range international CRAF aircraft. The aircraft chosen as the base aircraft will be given payload and speed factors of "1".

- All MV calculations are based on data submitted by carriers on AMC HQ Form 82, CRAF Aircraft Basic Data Sheet, and AMC HQ Form 83, CRAF Aircraft performance. These forms are part of the solicitation for airlift services and must be on file in HQ AMC/XOC in order to receive MV points.
- Cargo aircraft MV formula: MV=Payload Factor x Speed Factor x Daily Utilization Rate (10.0)
    - Payload Factor – the square root of the product of the weight factor and the cube factor
        - Cube Factor – the cubic feet of cargo space available on military 463L pallets on the main deck and in LD-3 containers in the lower lobe, divided by 4680 (the cubic feet of cargo space available on the base aircraft).
        - Weight factor – The payload, in tons, of an aircraft over 3500nm divided by 36.0 (the payload of the base aircraft).
    - Speed Factor – based on the aircraft's block speed over the standard range divided by 440 (the block speed of the base aircraft).
    - Daily utilization rate – the minimum number of hours of daily aircraft utilization for acceptance into the CRAF.
- Passenger/aeromedical aircraft MV (PMV/AMV) Formula: PMV/AMV=Payload Factor x Speed Factor x Daily Utilization Rate (10.0)

- The passenger payload factor is based on the smaller of either the company standard seating of the number of passengers; at 400 pounds each, the aircraft can carry the standard range (3500nm). The smaller of these two numbers is then divided by 165 (number of passengers on the base aircraft).

- After computing the MVs, each cargo and aeromedical evacuation aircraft receive full MV credit. Passenger aircraft receive prorated MV credit. The prorated MV credit for passenger aircraft is determined by multiplying the raw MV by a passenger MV multiplier.

  - The passenger MV multiplier is determined by dividing the total raw cargo MV points by the predetermined cargo percentage share of the AMC peacetime fixed buy airlift business. From the answer, subtract the total raw cargo MV points. Then divide the answer, which is the total allowed passenger MV points, by the total raw passenger MV points. The final answer is the MV multiplier.

Short-Range International, Domestic and Alaskan CRAF Computations. MV computations are based on maximum payload, in short tons, multiplied by the block speed, multiplied by the utilization rate, and then divided by 10,000 (a constant used to simplify the final number).

Time Period for Computing and Recomputing MV. MV will be initially computed after the carriers submit their AMC HQ Forms 82 and 83, then it may be recomputed once every six months, with the resulting MV points applying only to expansion business.[1]

Notes

[1] Air Mobility Command Regulation (AMCR) 55-8, *Operations, Civil Reserve Air Fleet (CRAF)* (Headquarters Air Mobility Command, Department of the Air Force, 15 August 1992), 12-3.

Glossary

AMC	Air Mobility Command
CAB	Civil Aeronautics Board
CAT	Crisis Action Team
CINF	Community Imagery Needs Forecast
CIP	Commercial Imagery Program
CIS	Commercial Imagery Strategy
CISO	Commercial Imagery Staff Office
CITO	Central Imagery Tasking Office
CRAF	Civil Reserve Air Fleet
CRIF	Commercial Reserve Imagery Fleet
DATA	Defense Air Transportation Administration
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation
EO	Executive Order
FEMA	Federal Emergency Management Agency
FIA	Future Imagery Architecture
FY	Fiscal Year
IC	Intelligence Community
LD/HD	low density/high demand
MAC	Military Airlift Command (now AMC)
MOU	Memorandum of Understanding
MTM	million ton miles
MV	Mobilization Value
NASA	National Aeronautics and Space Administration
NIMA	National Imagery and Mapping Agency
NRO	National Reconnaissance Office
PDD	Presidential Decision Directive

RMS	Requirements Management System
SPOT	Satellite Pour l'Observation de la Terre
TAG	Technical Advisory Group
TIROS	Television Infrared Observation Satellite
US	United States
USAF	United States Air Force
USGS	United States Geological Survey
USIGS	United States Imagery and Geospatial Information Service
WWI	World War I
WWII	World War II

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